The Australian mango breeding project

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The Australian mango industry is currently dominated by Kensington Pride which comprises some 80 per cent of all plantings. This is in contrast to other countries with modern export industries such as South Africa, Israel and Mexico, which are based on three to five cultivars. A joint venture between Agriculture Western Australia, the Queensland Department of Primary Industries (DPI), the Northern Territory Department of Primary Industries and Fisheries (DPIF) and the CSIRO commenced six years ago to generate a wide range of promising new mango hybrids that can meet both domestic and export market requirements. There has been considerable success to date.

Why the need for new mango varieties?

The cultivar Kensington Pride has several good attributes. Its distinctive fruit flavour and attractive presentation have made it popular with both the Australian domestic and export markets.

While this cultivar has wide consumer acceptance, it has a number of serious agronomic problems which impact greatly on the economics of production, including low irregular yields, excessive vigour (in tropical regions), short shelf-life and a susceptibility to a range of pre- and post-harvest disorders and diseases.

In addition, 95 per cent or more of all Kensington Pride seedlings are genetically identical. This lack of genetic variability has limited the opportunity to make further selections of higher yielding trees with better fruit quality.

Hybridisation of Kensington Pride and other cultivars with desirable traits offers a way to develop new cultivars that will also suit Australian growing conditions and markets.

Hybridisation program

In 1994, a hybridisation program began as a joint venture between Agriculture Western Australia, Queensland DPI, Northern Territory DPIF and CSIRO. The project was initiated under the guidance and training of Dr C.P.A. Iyer (CSIRO, McMaster Fellowship 1994).
The program aimed to develop cultivars with improved fruit quality and production characteristics that could meet domestic and export market requirements, and be suited to the various mango-growing regions in Australia. The broad objectives of the program were to develop cultivars that included some of the following characteristics:

- **Dwarfness** - reduced tree vigour and size is desirable as Kensington Pride is over-vigorous at the expense of cropping in the hotter growing districts.
- **High productivity** - mangoes generally have low productivity, and Kensington Pride is a low producer even in terms of mangoes, production averaging between 5 to 10 tonnes per hectare.
- **Fruit size (400 g)** - the current domestic market has a preference for fruit in the range from 325 to 400 grams making up tray counts of 18 to 20 fruit.
- **Fruit colour (good blush)** - both Australian and export markets prefer fruit with high blush.
- **Retention of the KP flavour** - the Australian market and many of our export markets recognise the unique flavour of Kensington Pride as the cultivar's greatest asset.
- **Reduced sap burn and post-harvest problems** - one of the greatest post-harvest fruit quality problems with Kensington Pride is skin browning and sap-related injuries.
- **Longer shelf-life** - lengthening of the storage times will improve access to export markets.
- **Reduced physiological disorders in the fruit** - physiological disorders in the current varieties are seen as a major fruit quality problem that is hard to control using management techniques. Susceptibility to specific forms of disorders is cultivar-related.
- **Early maturing** - cultivars that produce earlier than Kensington Pride have a distinct market advantage.
- **Reduced susceptibility to disease.**

It was recognised that not all of these objectives could be successfully bred into one cultivar, and that several generations of crossing would be required before this could be achieved.

As well as developing new hybrids for the market, the project was also aimed at studying the heritability of these characteristics. Very little work has been conducted on the heritability of mango characteristics in the past. Preliminary results have suggested that characteristics such as fruit flavour and colour have high heritability.

**Methods of breeding**

**Seedling selections**

Most existing commercial mango cultivars have resulted as chance selections from seedling progenies of known (almost all Florida cultivars) or unknown parentage (commercial Indian cultivars). This technique when employed in breeding programs often involves a large number of progenies.

The existing number of nearly 20 commercial cultivars grown in India has resulted after thousands of years of selection from millions of trees. There is still ample scope for improvement of these cultivars.

Selections from Florida are from a smaller number of progenies and are characterised by attractive colour but have other limitations. With the exception of Keitt, they have not been readily accepted in the Australian market. Most of them also suffer from the problems of developing small seedless fruits or 'nubbins', and post-harvest diseases.

Despite these limitations, there have been a few cases of successful selections. A seedling progeny of Kent, R2E2, is believed to be a natural cross with Kensington Pride and is being increasingly grown in Australia. Recently, one promising selection 'Celebration' of unknown parentage was identified near Darwin.
**Caging and planting parents in close proximity**

After identification of self-incompatibility in the Indian cultivar Dusehri, caging of this cultivar with other parents has been employed with some promising outcomes such as 'Mallika' and 'Amrapali'. More recently, this technique was employed in Israel.

One limitation of this technique is it necessitates synchronous flowering of the caged parent trees. Another way of achieving this objective is by planting the parents in close proximity to allow a higher probability of out-crossing. This technique is being adopted in a breeding project in southern Queensland, where some promising selections have been identified.

**Hand pollination**

Systematic crossing work was initiated in India in 1911 at Poona and later at several other centres. The main objective was to improve the yield of good quality cultivars by crossing with high yielding cultivars with medium quality. In earlier work, a large number of flowers were crossed on a few panicles (each panicle bears up to 6,000 flowers) resulting in a very small number of hybrids. Crossing fewer flowers on an increased number of panicles dramatically improved the outcome.

**Technique employed**

Kensington Pride was the dominant paternal parent used during the breeding project, although Nam Dok Mai and R2E2 were used with some crosses. Maternal parents were selected using several different criteria. Colour, growth habit, yield and flavour were the main factors influencing maternal parent selection. A selection of Florida and Indian cultivars were used such as Lippens, Tommy Atkins, Glenn, Haden, Irwin, Apple, H-10, Willard, Creeping and Padari. Crosses were made in Darwin, Kununurra and North Queensland.

The technique of crossing involved selection and preparation of panicles, emasculation of flowers in the female parent, collection of pollen from the male parent and transfer of pollen to the female parent. The basic technique was further improved by using gelatinous capsules to enclose the flowers after crossing.

On day one, panicles were selected in the late afternoon to avoid any adverse affect from high temperature. Panicles with healthy flower buds ready to open the next morning were selected (with already opened buds removed) and bagged while still on the tree to minimise pollen reaching the opening flowers.

On day two, pollen was collected from the male parent early in the morning. Five to ten hermaphrodite flowers were selected for crossing, and selected flowers were emasculated by plucking away their anthers. The stigma of the emasculated flower was then pollinated, and covered immediately to prevent airborne pollen reaching the flower.

**Parental compatibility**

In all areas, some problems were encountered between certain parents. Seasonal differences and technique probably accounted for some of these problems. Some crosses were 100 per cent unsuccessful, which may indicate incompatibility. However, further studies will be required to ascertain if this was the case.
New mango hybrids on display at a field day in Southedge, Queensland. (Above)

Cultivars Edward, Kensington Monoeembryonic and Magovar used for maternal parents crossed with Kensington Pride were 100 per cent unsuccessful. Cultivars Tommy Atkins and Glenn generally had very low success rates, but this did vary between seasons and districts. Bunch-bearing cultivars such as Creeping and Willard generally achieved the highest success with in excess of 25 per cent of panicles producing hybrids.

Conclusions

Development phases

The project was divided into three phases of development.

1. Hybridisation

This work ran for four years from 1994 to 1997. It generated over 1,800 hybrids, produced from 42 parental combinations using predominantly Kensington, Floridian and Indian cultivars for the parents.

2. Initial selection

The second phase of the program involved an initial screening of hybrids for desirable types at the two sites, Southedge Research Station, Mareeba, in Queensland and Coastal Plains Research Station, Darwin, in the Northern Territory.

Southedge was chosen for its cooler night temperatures and elevation. This, combined with grafted trees, helped the hybrids come into flower at a younger age than the warmer areas, thus speeding up this phase of the project. The Darwin planting enabled a comparative assessment of the hybrids under warmer conditions, although trees fruited at a later age.

This season, in excess of 300 hybrids fruited, with some looking extremely promising by displaying excellent colour and many retaining the characteristic Kensington flavour. Hybrids will be assessed to generate outstanding cultivars in each of the Kensington, Indian and Florida groups to suit different market needs.

3. Detailed testing

The third phase of the program will involve larger scale planting of replicated trials in each agro-climatic region to compare and evaluate the most desirable selections from the initial screening phase. Data gained from these trials will be used to evaluate plant and fruit characteristics under the different climatic conditions, and to prepare applications for plant breeder’s rights.

Final outcomes

The project has been running for six years and has very successfully generated a wide range of promising hybrids. In the past season, six hybrids passed the detailed initial selection process and are being propagated for inclusion in phase-three evaluation.

This phase of regional evaluation and market testing is likely to take another five years. The end result will be several new varieties making it to the final phase of commercialisation and release, which will provide an improved product to growers and consumers alike.